Spirometry in the primary care setting

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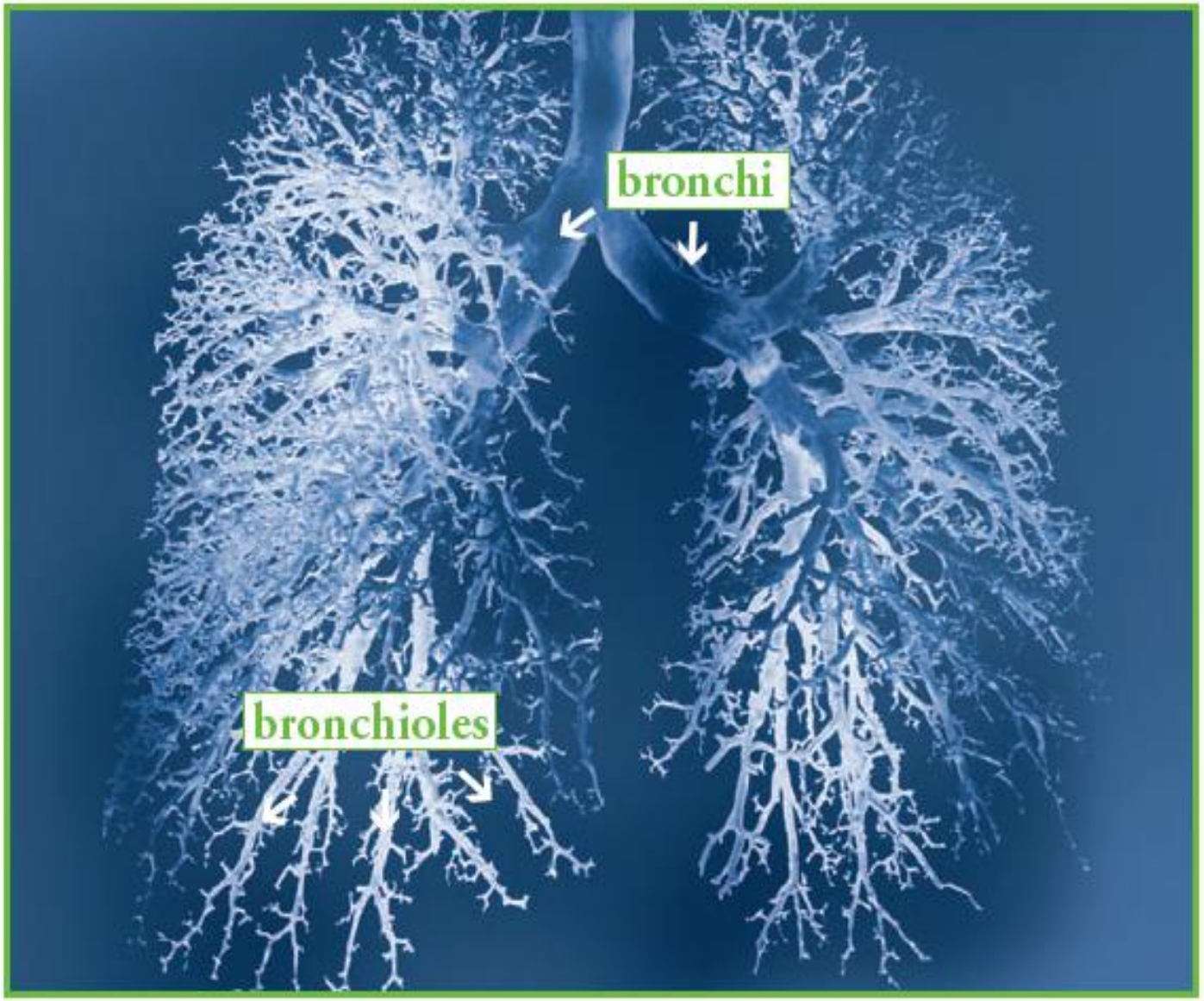
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bronchioles

Spirometry in the primary care setting

Spirometry measurements

Anatomy, pathology, growth and aging

Testing procedures

Bronchodilator reversibility testing

Normal and abnormal patterns

Classifying asthma severity

Flow Volume loops

Why Pulmonary Function Testing???

Diabetes care requires measurements of serum glucose and hemoglobin A1c

Care for hypertension requires measurements of a patients blood pressure

Treatment for dyslipidemia requires measurements of serum lipids

Lung disease care requires measurement of pulmonary function tests (PFT's)

Why Pulmonary Function Testing???

Asthma incidence continues to grow

COPD is the 4th leading cause of death and the only increasing cause in the top 10

PFT's can provide early diagnosis of lung disease, and assist in evaluation of treatment effectiveness

PFT's are greatly underutilized, and can be helpful in making early interventions

PFT's can answer some of these questions!!!

- Is a patients lung function impaired? Is airway obstruction present? How severe is it? Does it respond to broncho- dilators? Is treatment helping the patient? How great is the surgical risk?
- Does a patient have asthma or COPD? Does a patient have exercise induced asthma? Is a patient's cough a sign of occult asthma?

PFT's can do the following:

- PFT's are the objective tool now available to assess asthma, COPD and other pulmonary diseases.
- PFT's lend credibility to prior subjective efforts that were often based on symptom frequency, used of rescue inhalers, and presence of wheezing on physical exam.

PFT's can do the following:

- PFT's help to diagnose and manage obstructive and restrictive lung disease.
- PFT's are useful for measuring and monitoring responses to therapy for asthma and chronic obstructive pulmonary disease (COPD).

What do PFT's measure?

- How much air an individual can blow out, and how fast.
- Spirometry provides two numeric values that are helpful in the assessment and monitoring of patients with compromised lung function:

What do PFT's measure?

- Forced Vital Capacity (FVC)
- Forced Expiratory Volume measured over 1 second (FEV1).
- Airway obstruction is characterized by a decrease in the FEV1/FVC ratio.

Forced Vital Capacity (FVC)

- The total amount of air that can be exhaled following as deep an inhalation as possible.
- Patients must try to exhale for at least 6 seconds to obtain a useful FVC measurement.
- Height, age, sex, and race are the primary factors influencing a “normal” FVC value. 80-120% of predicted is the normal range

Forced Expiratory Volume in 1 second (FEV1)

- The FEV1 measures flow (and volume) during the first second of an FVC maneuver and is often considered the most important variable. Measures large airway function
- FEV1 declines in direct and linear proportion with worsening of airways obstruction.
- FEV1 increases as obstruction is successfully treated.

Forced Expiratory Volume in 1 second (FEV1)

- FEV1 is used to determine the degree of obstruction, (mild, moderate or severe).
- FEV1 should be used for serial comparisons when following patients with asthma or COPD.
- Patients should be told their FEV1 percent of predicted.

FEV1/FVC Ratio or FEV1%

- How much of the FVC is blown out during the first second
- FEV1/FVC ratio is the most sensitive parameter for detecting airways obstruction in its early stages.
- A ratio of less than 70% in adults and 80% in children indicates airway obstruction.
- Once a pattern of airways obstruction is established, the ratio can be ignored during follow-up examinations.

FEF 25-75 or MMEF

- Measures flow generated during the middle portion of expiratory effort
- Controversial value
- Indicates small airway function
- Least effort dependent result
- Also known as Maximal Mid Expiratory Flow (MMEF)
- May be more valuable in children than the FEV1/FVC ratio

Airways Anatomy & Pathology

- Extrathoracic airway includes:
  - Mouth, Pharynx, Vocal Cords, Upper trachea (in the neck)
- Intrathoracic airway includes:
  - Lower trachea (within the chest), the carina, branching airways located in the lungs
- Large and small (less than 2mm) airways
  - Chronic inflammation from smoking and eosinophilic inflammation with asthma involve both large and small airways

Airways Anatomy & Pathology

- Asthma induced acute bronchospasm
  - Airway narrowing by smooth muscle contraction
  - Audible wheezing during exhalation
- Chronic asthma and chronic bronchitis
  - airway edema and excess mucus secretion
  - airway narrowing and ventilation disruption
  - uneven airway emptying with reduced airflow during forced exhalation

Airways Anatomy & Pathology

- Chronic Obstructive Pulmonary Disease
  - Includes emphysema and chronic bronchitis
  - Develops over decades in 1 of 5 smokers
  - Destruction of lung parenchyma with loss of elasticity and diminished airways support
- Upper airway narrowing
  - Vocal cord paralysis or dysfunction
  - Compression due to tumors

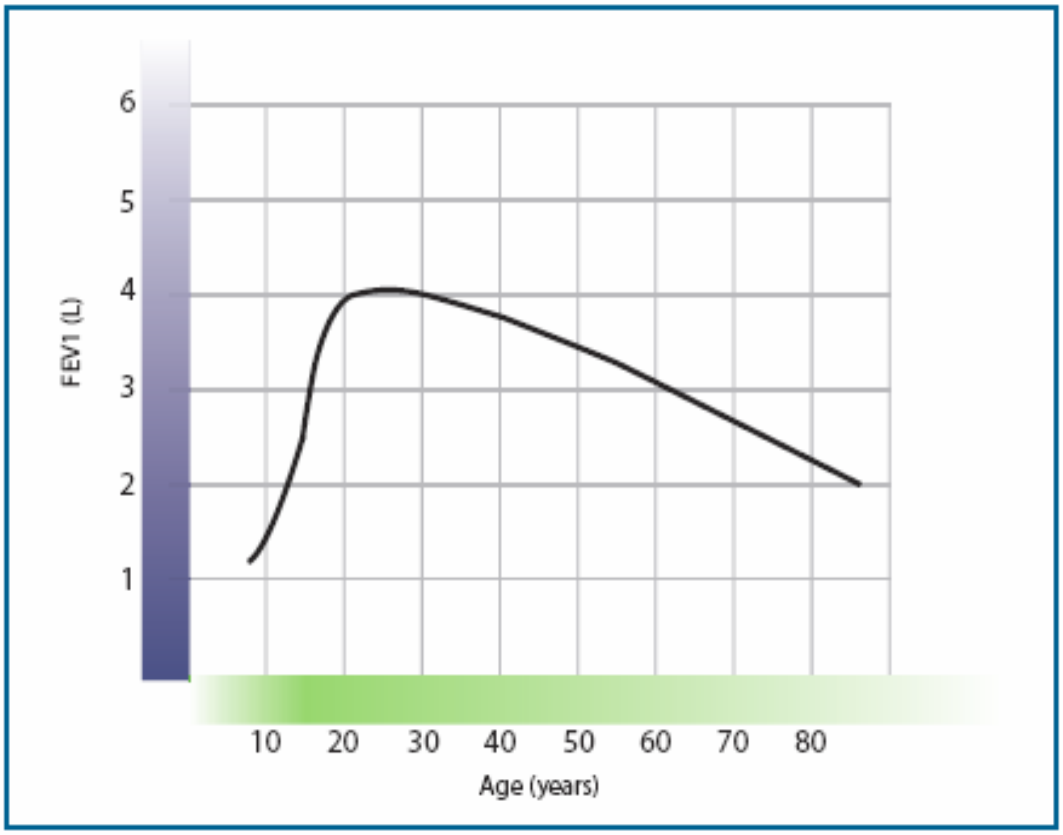
Growth and Aging of the Lungs

- Lung Growth
  - Parallels exponential increase in height of children and teenagers
  - Peaks during 20's and 30's
  - Slow decline in FVC and FEV1 extending throughout adulthood
  - Smoking, CF, infections, malnutrition and occupational exposures may slow growth
  - Regular aerobic exercise may enhance lung growth

Growth and Aging of the Lungs

- Aging
  - After age 30, lung tissue begins to lose elasticity
  - Airways begin to close prematurely
  - FVC decreases by about 0.20 liter per decade
  - Many diseases can cause FVC to fall more quickly
  - Smokers with COPD may lose FVC at the rate of 0.50 liter per decade

Normal Growth and Subsequent Decline in Lung Function in a Male of Average Height



Clinical Uses for Diagnostic Spirometry

Spirometry is the most useful test for detecting and managing asthma and COPD. Spirometry is also indicated for use in several other clinical situations commonly encountered by medical practitioners:

- Diagnosing asthma
- Categorizing asthma severity
- Identifying adult smokers who are developing COPD
- Staging the severity of COPD
- Chronic dyspnea workup
- Diagnosing restrictive lung disease
- Detecting bronchial hyper-responsiveness
- Measuring the effectiveness of bronchodilator or corticosteroid therapy
- Evaluating the pulmonary effects of workplace exposure to irritants
- Determining the risk of postoperative pulmonary complications
- Measuring the degree of impairment from respiratory disease

Testing Procedures

- Testing techniques
  - Explain the procedure
  - Demonstrate the technique
  - Coach the patient for maximum effort
  - Encourage continued blowing for 6 seconds
  - Correct the patients technique, if needed
  - Obtain 3 good efforts, 2 of which match closely

Blow, Blow, Blow, Blow, Blow----

- Squeeze, squeeze, squeeze,
- Keep pushing, keep pushing,
- Blow, Blow,
- Keep going, keep going, keep going
  - Coach patient with body language
  - and assertive verbal prompts

Bronchodilator Testing

- If airway obstruction is detected
- If asthma is suspected, even with normal results of pre-BD testing
- Short acting bronchodilator (Albuterol)
  - 2-3 puffs of Albuterol using spacer device
  - Wait 15-30 minutes after inhalation to do post-bronchodilator testing
  - 12% improvement in FEV1 or FVC ***and*** 200ml is required to document reversibility
  - Patients may still benefit from bronchodilator therapy, even if response is less than 12%

Bronchodilator Testing

- Incorrect results or misleading interpretations can result if baseline or post-BD efforts are of poor quality
- Evaluation of spirometer tracing, and correlation with patients history is required to interpret test results.
- Spirometry “Normals” can vary by up to 20%. A patient’s normal range is anywhere from 80-120% of their predicted values

Graphing of FVC Maneuvers

- Volume-time (V-T) Curve
  - Allows easy measurement of FEV1
  - Reaches a plateau, ending in the FVC
- Flow-Volume (F-V) Curve
  - Easy to “read” airways obstruction
  - Easily recognized poor expiratory effort
- Both allow easy to read FVC

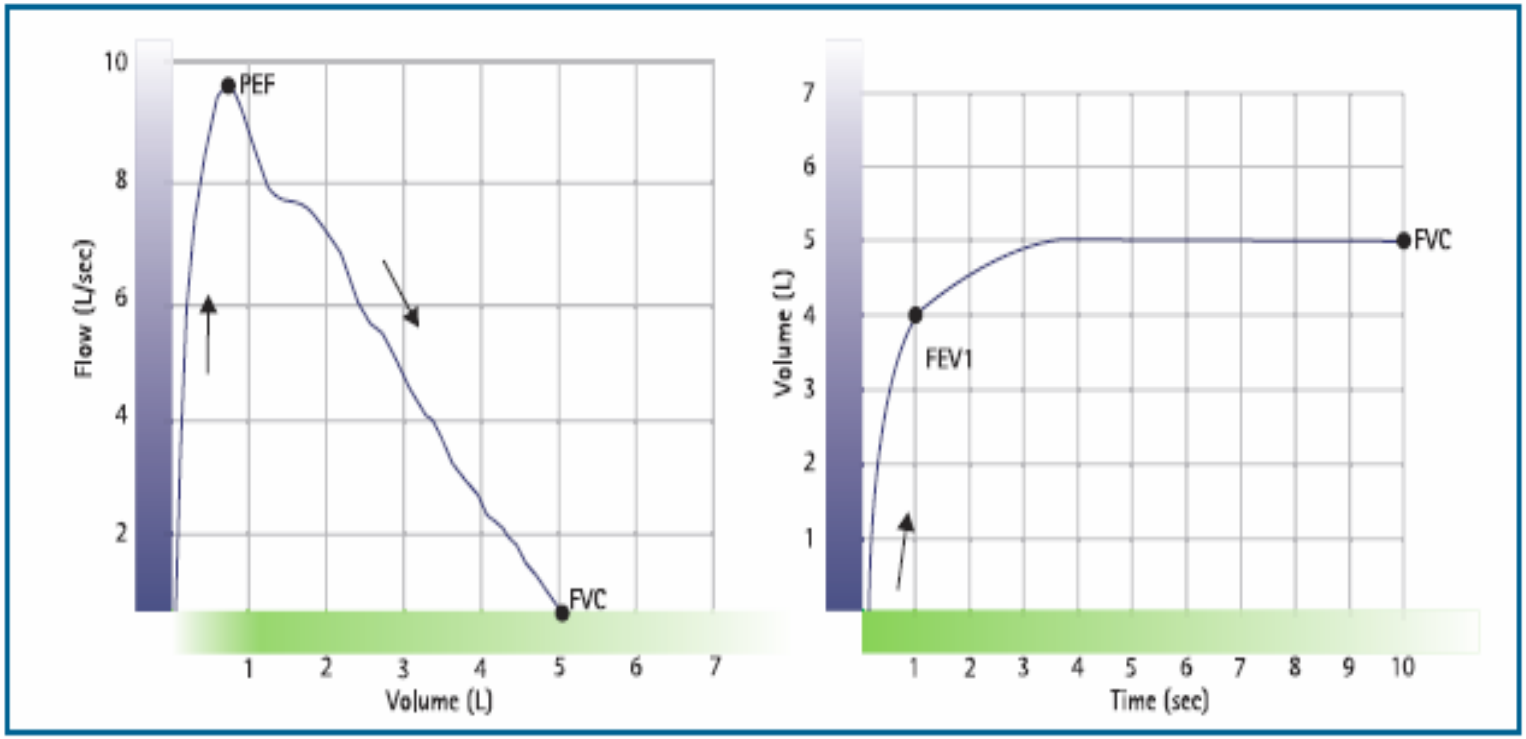
Graphing of FVC Maneuvers

- Peak Expiratory Flow (PEF) or (PEFR)
  - Seen at the top of F-V curve
  - Measured in Liters/Second on spirometers
  - Measured in Liters/Minute on hand-held home monitoring instruments
- May be reduced in obstructive and restrictive lung diseases
- Less specific, less sensitive and less accurate compared to FVC and FEV1

Normal Pattern

- Sail shaped F-V curve
  - Quickly reaches “peak” then flow drops off at a steady rate
- 90 degree curve (or close to it) rise in V-T curve
  - 80% of FVC exhaled in first second

Normal Pattern: N



Obstructive Pattern: Ob

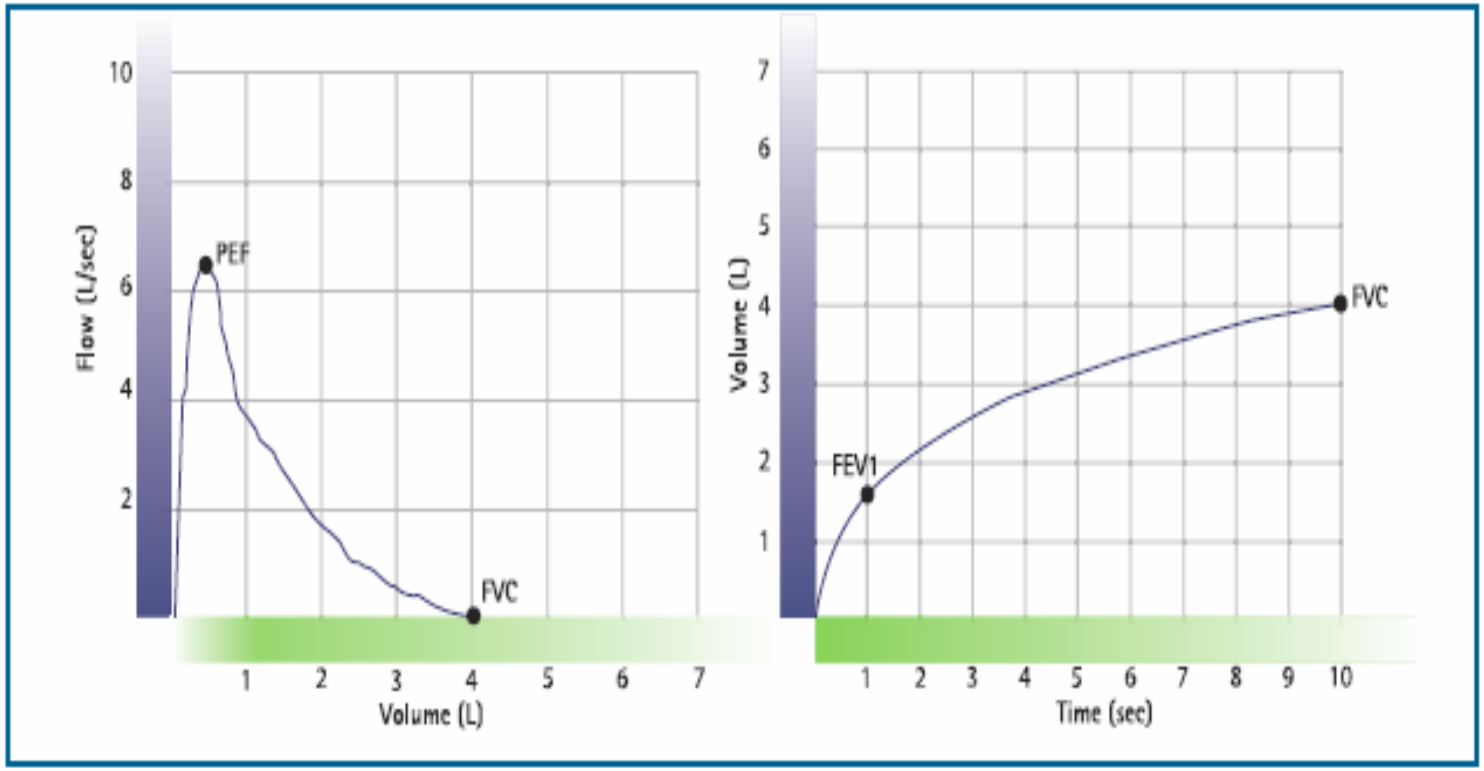
Spirometry in healthy people

- Healthy people inhale maximally and exhale quickly, without obstruction
- Normal FVC and FEV1 (80-120%) of normal predicted value for their height, sex, age, race and weight
- FEV1/FVC ratio approximately 80% or greater for kids, 70% or greater for adults

Obstructive Pattern

- Bowl shaped pattern of F-V curve
  - Quickly reaches “peak” then scoops or droops downward.
  - Flow becomes very low as it approaches the FVC, may look like a rat’s tail in patients with severe airways obstruction (usually COPD)
- V-T curve pattern is more subtle, takes more time to exhale and curve may continue to rise, never reaching a flat plateau

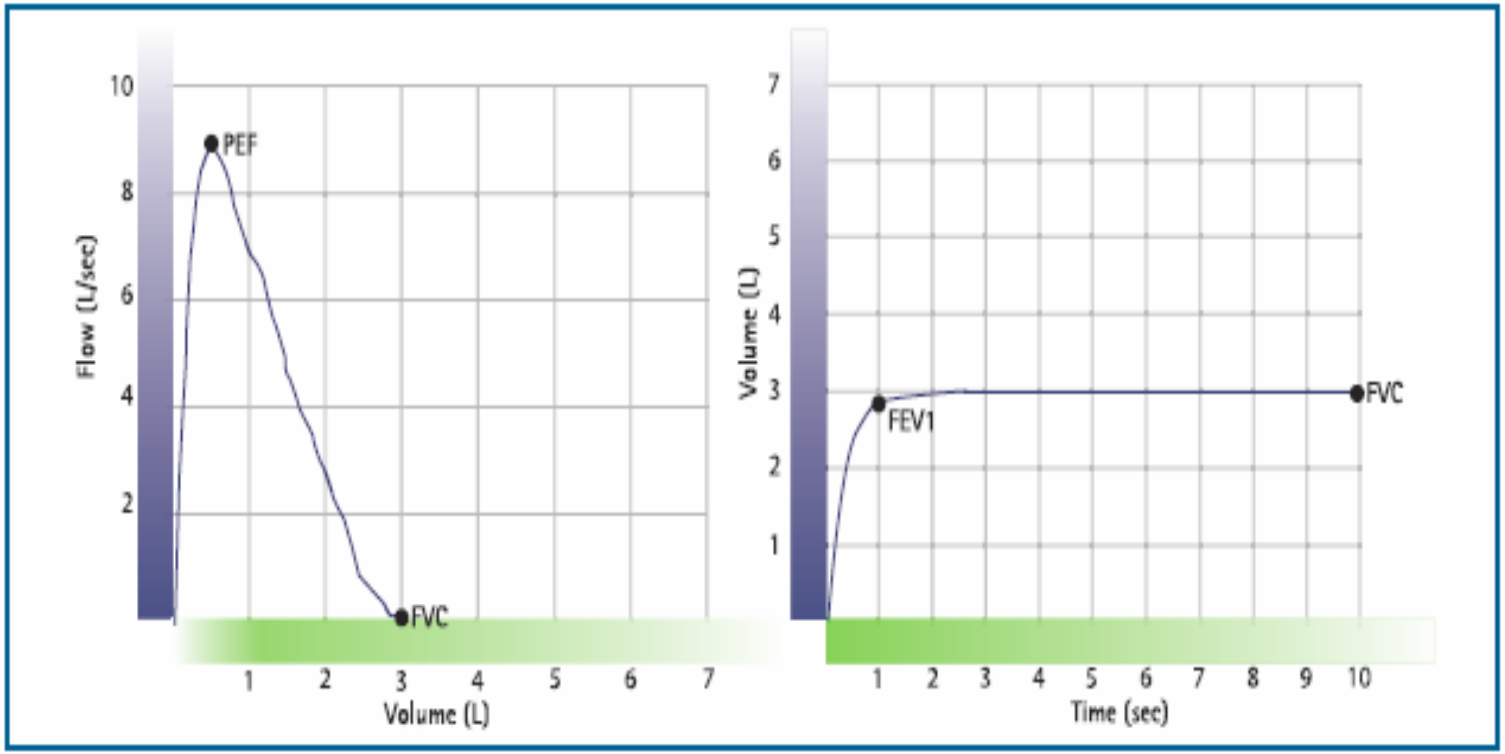
Obstructive Pattern: Obs



Restrictive Pattern

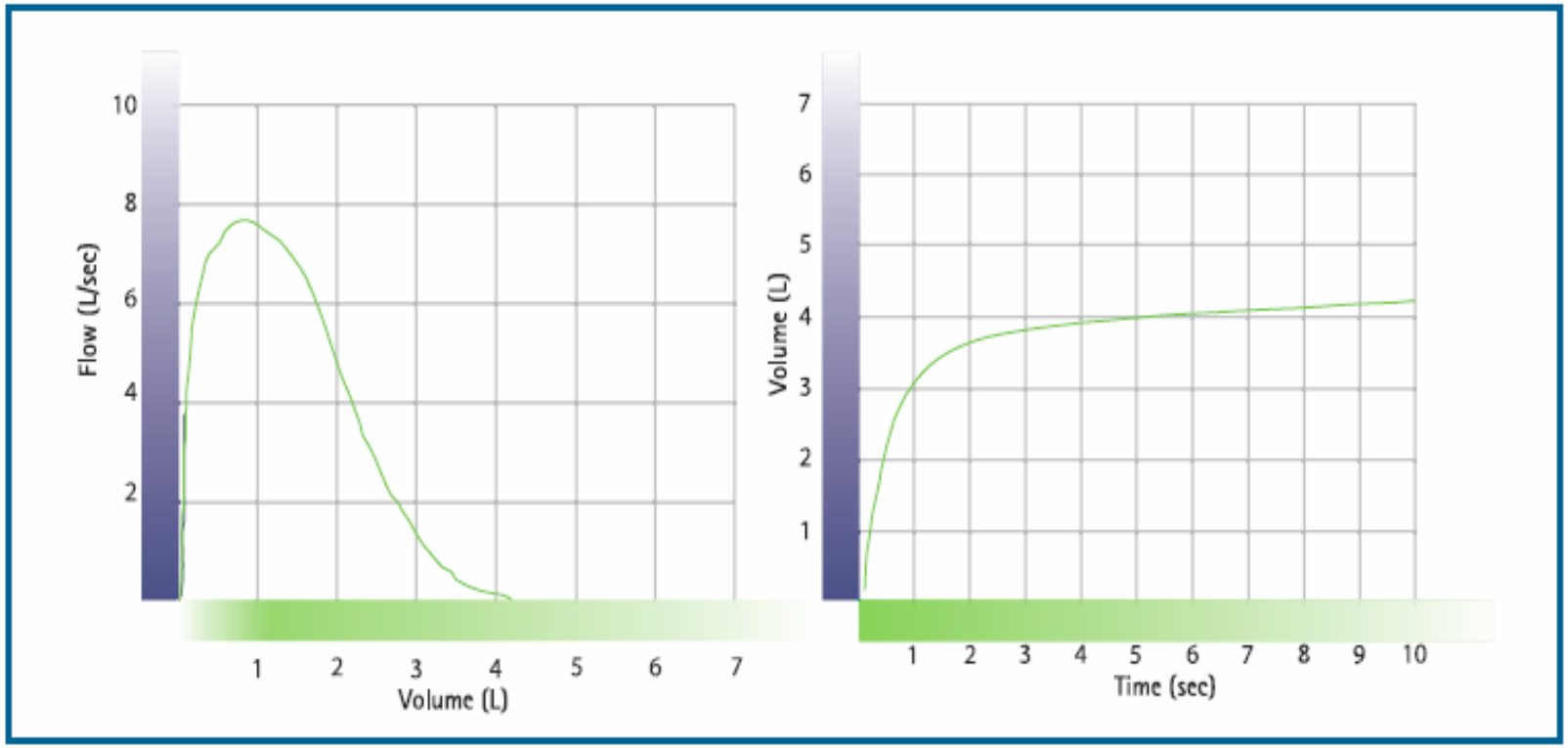
- Low FVC is the hallmark of restriction
- Steep F-V curve, may resemble tip of a missile or the Transamerica building
  - Quickly reaches “peak” then steeper decline than normal as air is exhaled quickly
- V-T curve may look “normal”, however the flat plateau is lower than normal and may be reached in 1 or 2 seconds

Restrictive Pattern: RINO (Reduced Inflation, No Obstruction)



Patient examples

- 81 yo male requests a “lung test” during routine clinic visit for removal of bunion
- No respiratory problems reported, but He wants to know if his lungs are still working OK
- PE results are WNL, with no physical abnormalities


Flow (L/sec)
10
8
6
4
2
1 2 3 4 5 6 7
Volume (L)
Volume (L)
7
6
5
4
3
2
1
1 2 3 4 5 6 7 8 9 10
Time (sec)

		% of Predicted
FVC	4.2 L	127
FEV1	3.1 L	114
FEV1/FVC (%)	74%	

Pattern: N

High quality spirometry test

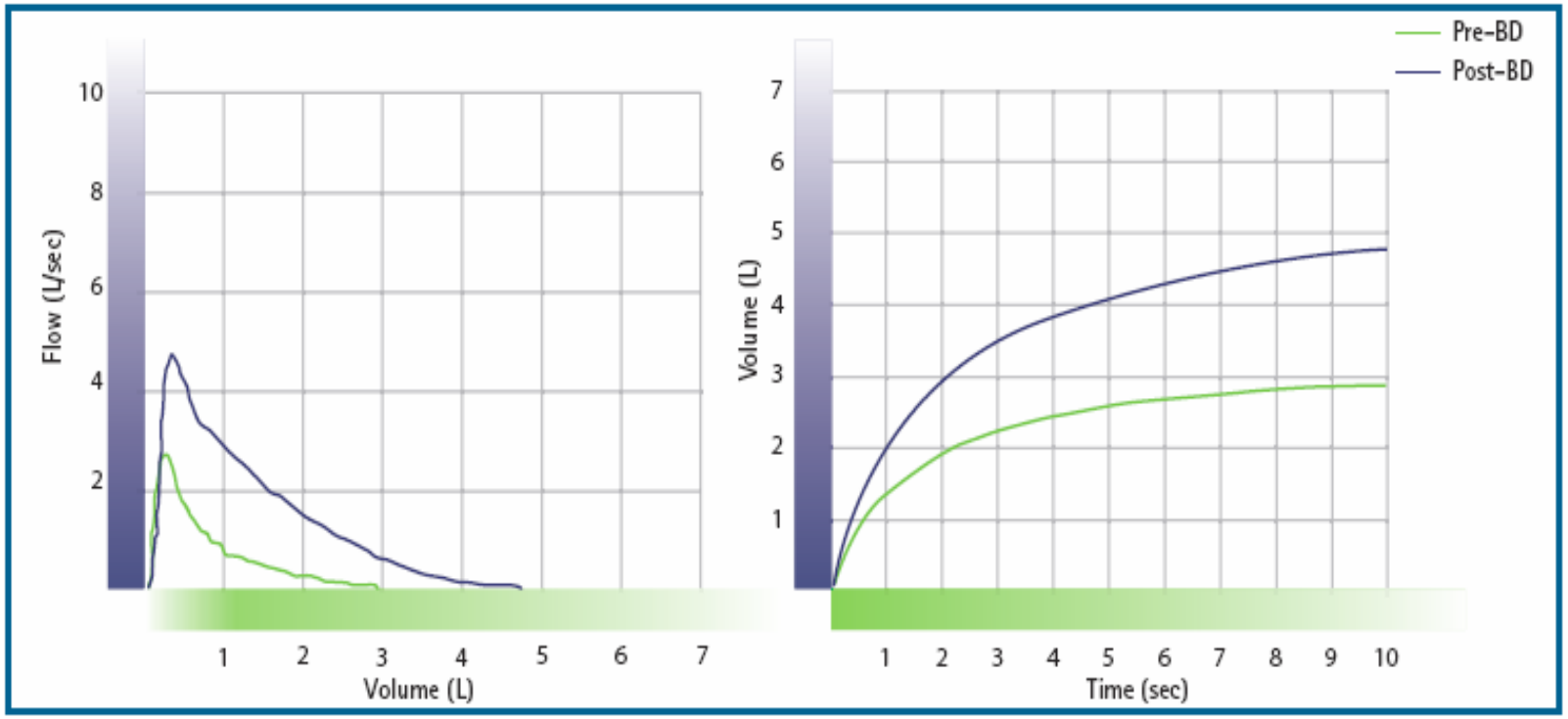
Sharp peak of F-V curve

Normal FVC, FEV1 and FEV1/FVC ratio

No post-bronchodilator testing performed

45 yo female with chronic cough, mostly at night for more than 2 years

- Occasional SOB while climbing stairs
- more recently has had cough, chest tightness and SOB walking on level ground
- 1 Pack/day smoker age 18-40, quit when her brother was diagnosed with emphysema
- Another brother had asthma in childhood, but outgrew it in high school
- Denies allergies or workplace exposures
- Lung sounds are clear



	Pre-BD*	% of Predicted	Post-BD	% of Predicted
FVC	2.9 L	57	4.7 L	92
FEV1	1.2 L	28	2.3 L	53
FEV1/FVC	41%		49%	

Pattern: Obs, BD+

History is consistent with COPD, asthma, GERD, or a combination

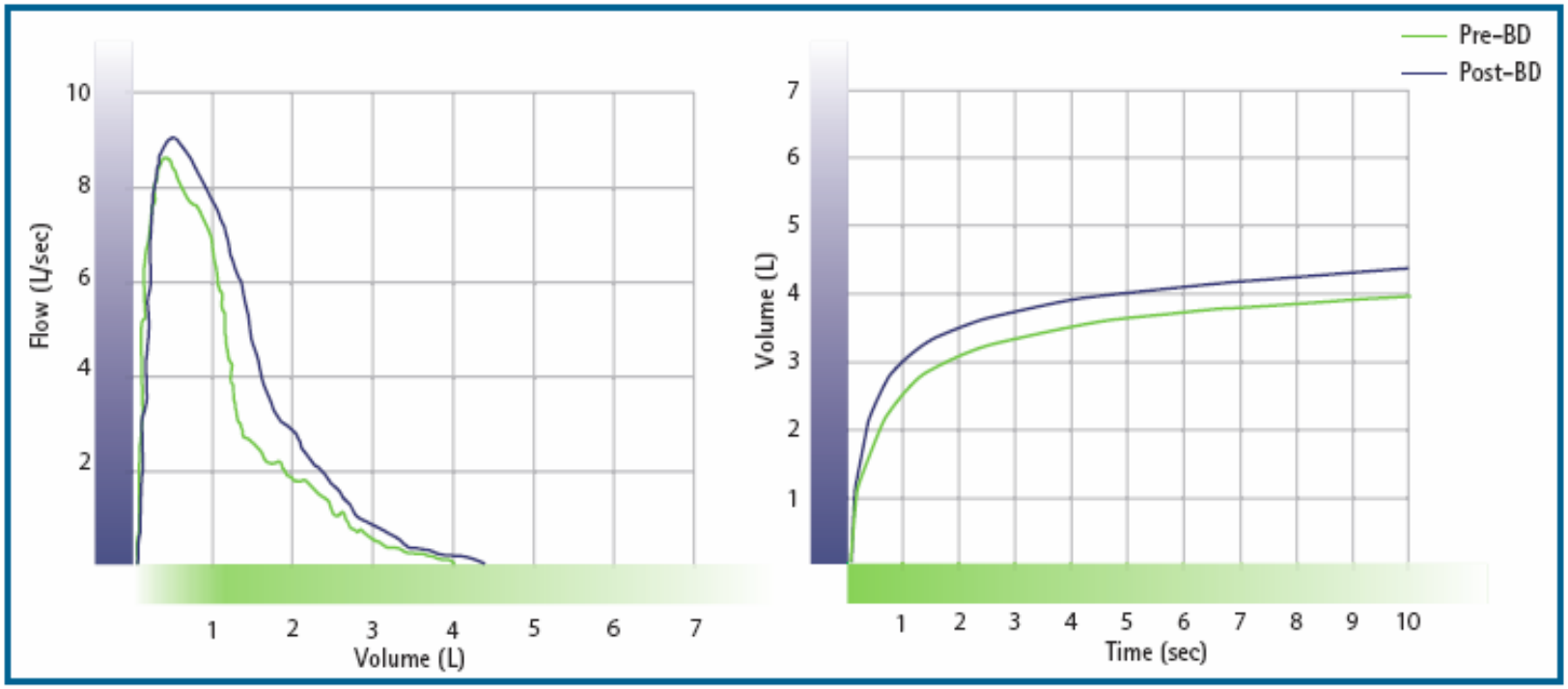
- Severe airways obstruction shown by drooping/scooping pattern of F-V curve
- Low FEV1/FVC ratio of 41% verifies this
- Consistent with COPD or asthma
- FEV1 almost doubles post B-D, confirming diagnosis of asthma
- She is likely to do well with use of an asthma controller medication

Categorizing asthma severity

- PFT's can help to determine severity of asthma and the degree of disease control
- FEV1 above 80% indicates mild asthma, or reasonable control for those on an asthma controller medication
- FEV1 between 60-80% suggests moderate persistent or poorly controlled asthma
- FEV1 below 60% suggests severe persistent or uncontrolled asthma

32 yo school teacher with lifelong HX of mild, intermittent asthma, occasional rescue inhaler needed

- URI 2 months ago with chest tightness and wheezing, responded promptly to inhaled albuterol, QID for 1 week
- Since then she reports awakening with cough and mild SOB about once per week
- PE results are normal, lungs are clear
- HX sounds like intermittent asthma, but you decide to proceed with spirometry, just to be sure



	Pre-BD	% of Predicted	Post-BD	% of Predicted
FVC	4.0 L	93	4.4 L	102
FEV1	2.5 L	71	3.0 L	86
FEV1/FVC	63%		68%	

Pattern: Obs, BD+

High peak flow of 8.5L/sec

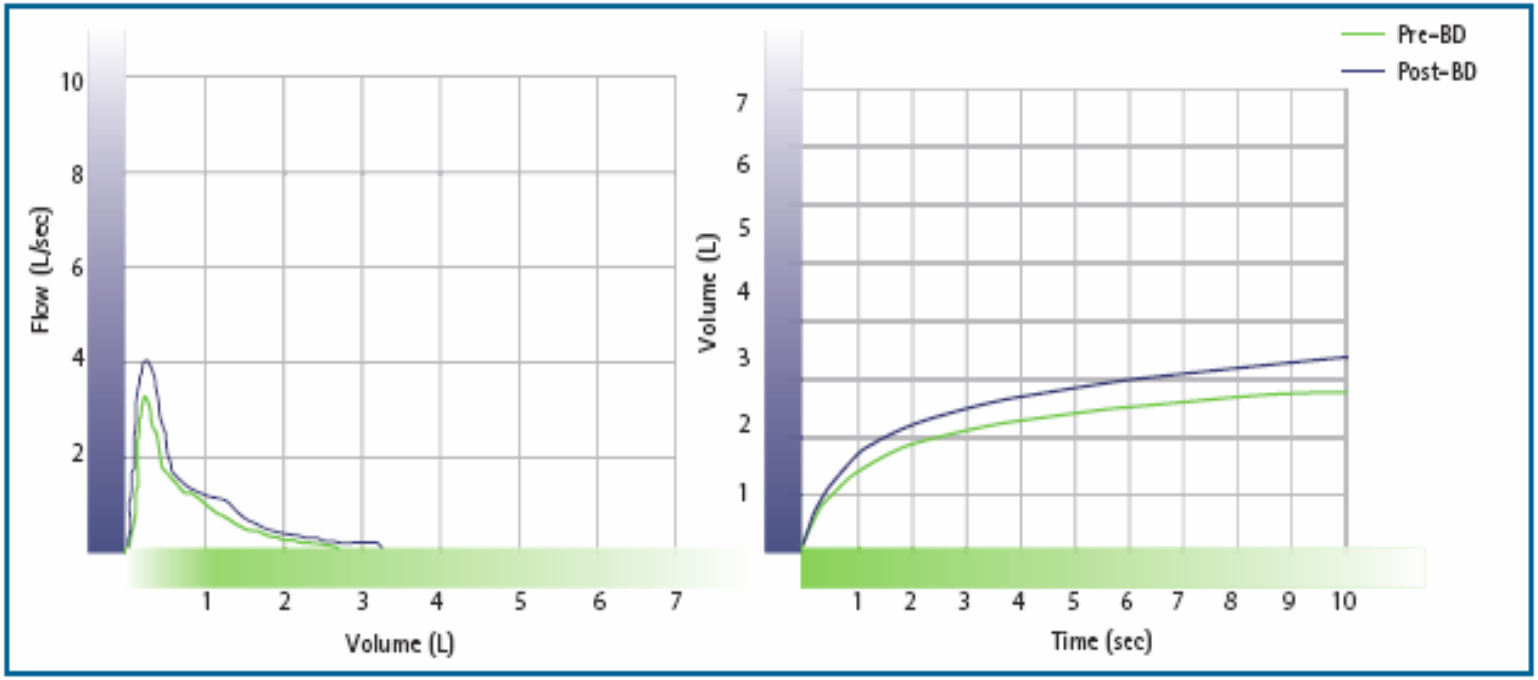
- Bowl shaped F-V curve is characteristic of airways obstruction verified by low FEV1/FVC
- FEV1 is 71% pre-BD, increasing to 86% post-BD, a full 20% and 500ml
- Pre-BD test indicates moderate, persistent asthma
- 2 month F/U she reports exercising without coughing or chest tightness, no rescue inhaler use and PFT's are normal

Detecting COPD in adult smokers

- PFTs are the best way to detect borderline to mild airways obstruction of early COPD
- FEV1/FVC ratio is below 70% even after administration of a bronchodilator
- Once the diagnosis of COPD is made, the course of COPD (or response to therapy) is best followed by measuring changes in the FEV1
- Continued smoking can lead to abnormally rapid decline in FEV1 (more than 0.5L/decade)
- Smoking cessation usually halts rapid decline

52yo smoker with chronic cough and morning sputum production for 5 years

- Patient does not exercise and denies ever being short of breath
- She reports “perfect health” other than her cough and sputum production
- She takes estrogen replacement meds
- PE is normal, but you notice excessive facial wrinkling, moderate obesity and yellow staining of her right index finger



	Pre-BD	% of Predicted	Post-BD	% of Predicted
FVC	2.7 L	63	3.3 L	77
FEV1	1.3 L	38	1.6 L	47
FEV1/FVC	48%		48%	

Pattern: Obs, BD-

May be mixed obstruction of COPD and asthma

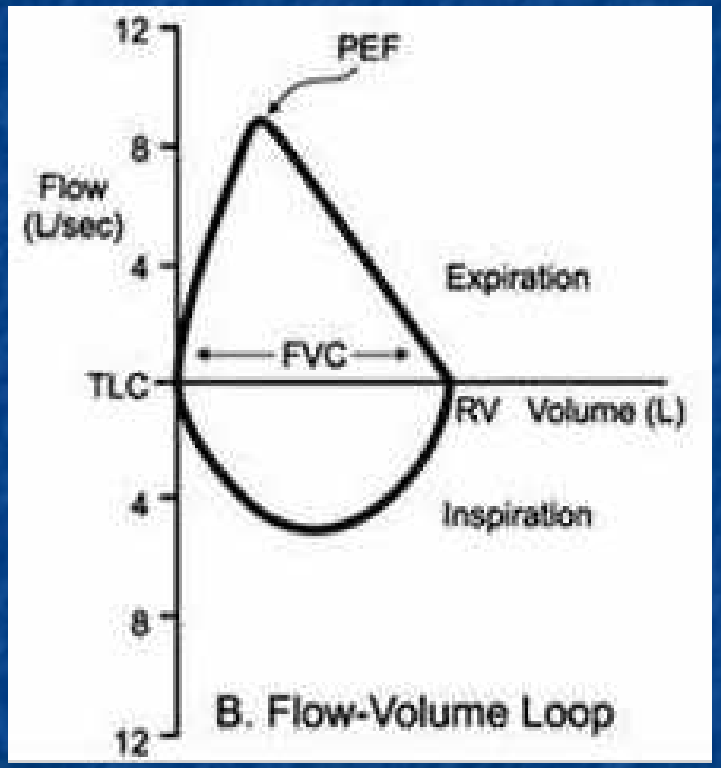
- Severe airways obstruction with rat's tail shape to her F-V curve
- Repeat PFT, 30 minutes after albuterol and ipratropium, her FEV1 increases moderately but her ratio remains the same
- She admits smoking since age 17 and wants to quit
- You diagnose COPD, prescribe Chantix and refer her to a smoking cessation program

Spirometry vs. Peak Flow Meter

- Spirometry is used for diagnosis and management
- Peak flow meter is used for monitoring only
  - Measures only large airway function
  - No graphic display or printout
  - No regular calibration

Flow-volume loops

- Is a plot of inspiratory and expiratory flow in the vertical axis against volume in the horizontal axis, during the performance of maximally forced inspiratory and expiratory maneuvers.



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Questions?

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